[illegible] 1894

On Julinia; a New Genus of Compound Ascidians from the Antarctic Ocean.

By

W. T. Calman,
University College, Dundee.

With Plates 1—3.

The Ascidian described in the present paper was collected in the Antarctic Ocean by Dr. C. M. Donald, of the whaler "Active," during the Dundee Whaling Expedition of 1892–93, and was placed along with other specimens in Professor D'Arcy W. Thompson's hands. Its large size and remarkable appearance attracted attention, and closer examination suggested its possible identity with the species described by Professor Herdman in his report on the Compound Ascidians of the Challenger Expedition ('Chall. Rep.,' vol. xiv, pp 250) as ——— (?) ignotus. The specimens on which this species was then tentatively founded, two of them in the Challenger collection and the third in the British Museum, were in an unsatisfactory state of preservation, so that Professor Herdman was unable to determine the genus, or even with certainty the family, to which the species belonged. Our specimen was preserved simply in methylated spirit, but on sectioning it was found to be in a better state than might have been anticipated, giving good results with the usual stains and making possible a fairly complete study of its anatomy. In the following description, Maurice's monograph on Fragaroides ('Arch. de Biol.,' viii, pp. 205—495) has been used for comparison throughout, as being the most complete account we possess of the structure of a Compound Ascidian.

Our species, whose relation to Professor Herdman's —— (?) ignotus I shall again return to, evidently forms the type of a new genus, which at the suggestion of Professor D'Arcy Thompson (under whose guidance this paper has been prepared), I propose to dedicate, under the name of Julinia, to the learned naturalist whose researches on the subneural gland and other anatomical features form classical contributions to our knowledge of the Ascidians.

The specimen was found floating on the surface of the sea in the north of Erebus and Terror Gulf, and Dr. Donald tells me that considerable quantities were seen. As there is nothing in its structure to suggest a pelagic mode of life, the colonies may have been torn from their submarine attachment in shallow water. At the same time the remarkable genus Cœlocormus must be remembered as showing the possibility of a Compound Ascidian leading an unattached life though destitute of any special means of locomotion; moreover in the present case the extreme elongation of the colony renders it improbable that it could have been supported by a narrow base of attachment.

External Appearance and General Features of the Colony.

The colony is irregularly cylindrical in shape (Pl. 1, fig. 1), measuring 78·5 cm. in length and from 1·5 to 2·5 cm. in diameter. One end is torn and ragged, while the other is slightly tapered and smoothly rounded. No attaching fibres such as Herdman describes are preserved. Over large areas, particularly along one side, the surface presents a decayed appearance, the zooids being absent or scattered here and there and partially macerated. Over the rest of the surface the zooids are arranged in fairly regular round or oval systems (Pl. 1, fig. 2), each comprising from about six to twelve zooids. The colour of the whole is yellowish with a tint as though in life it had been orange, the zooids appearing as lighter spots. The buccal orifices are small and six-lobed. In the centre of each system is a large and irregularly-lobed common cloacal opening.

In a transverse section through the colony (Pl. 1, fig. 9) the zooids are seen arranged round the circumference. From their proximal ends vascular processes pass inwards, branching and interlacing in the interior of the colony. In the further structure of the framework of the colony we have to deal with a number of elements more or less obscure, which may be briefly enumerated but which remain here as in other cases imperfectly understood. Just below the ascidiozooids large numbers of peculiar vesicles occur scattered among the vessels. These vesicles are spherical, from ·3 to ·7 mm. in diameter, and consist of a denser layer of the test-substance surrounding a granular mass of variable size and appearance, in which numerous nuclei are occasionally found. It is possible that these masses may represent degenerating zooids like those described by Maurice in Fragaroides, though their great abundance is rather against this view. Many buds in different stages of development occur scattered among these vesicles. The centre or core of the colony is composed of the spongy test-substance, traversed by the vascular processes, which here run more or less in a longitudinal direction.

In its minute structure the test resembles that described by Herdman in Colella (l. c., p. 78). In section (Pl. 3, fig. 32) it presents a reticulate appearance, the cavities occupied by the large vesicular or vacuolated cells known as "bladder-cells" reducing the matrix to a mere interstitial network. These "bladder-cells" are of common, but not universal occurrence among Compound Ascidians.

In the immediate neighbourhood of the zooids and of the vascular processes the tissue is denser, forming tracts of homogeneous matrix-substance which show, besides a few bladder-cells, small test-cells of the more usual type, with scanty protoplasm and irregular outline. Near the surface of the colony numerous groups of yellowish pigment-cells occur. These are irregularly rounded (probably shrivelled by the spirit), highly refracting, and apparently homogeneous. In the deeper parts of the colony are found scattered here and there a few small crystalline masses (Pl. 1, fig. 11). These bodies dissolved somewhat slowly and without effervescence in hydrochloric acid, but on account of their small number their chemical nature could not be definitely ascertained, and they cannot be certainly assumed to represent the stellate calcareous spicules, e.g. of the Didemnidæ.

Scattered here and there in the test-substance are groups or nests of rather large cells (Pl. 1, fig. 10) containing rounded deeply staining masses of varying size and appearance. The protoplasm is often very granular, and no nucleus is visible. It is possible that these obscure bodies represent the test-phagocytes of Maurice, to which he ascribes the function of absorbing the dead zooids, but it is to be noted that here they do not occur in relation to the masses described above as possibly representing degenerated zooids.

General Conformation of the Ascidiozooids.

The body (Pl. 1, fig. 3) is divided into two regions, the thorax and abdomen, united by a narrow neck. The thoracic region contains the branchial sac, and varies in shape according to the state of contraction. In the most expanded specimens it is roughly square-shaped when seen from the side, and broadly oval in transverse section (Pl. 2, fig. 14). A number of longitudinal muscle-bands run in the mantle, about four to six on each side. Along the ventral edge of the thorax runs the large undulating endostyle. On the dorsal surface of the animal is the wide atrial orifice, behind which is attached the vesicle described below as probably representing an incubatory pouch. In front of the atrial orifice is the very large atrial languet. The languets belonging to the several zooids of a system meet at their edges to form a composite roof to the common cloacal chamber; seen from the outside this roof is hidden by a continuation of the common test, in the centre of which is the common cloacal opening.

As a result of this arrangement, the individual languets are somewhat irregular in shape. There appears to be no such continuation of the test-substance on the lower surface of the languets as is seen in Fragaroides. In the abdomen the loop of the gut lies transversely to the dorso-ventral axis, the oval stomach being on the right side. On the dorsal side of the loop is the ovary, containing one or two large orange-coloured ova. In front of this the opaque white vas deferens leads forwards to the cloaca. The heart in its pericardium lies on the ventral side of the abdomen.

Branchial Cavity.—The buccal siphon is short, ending in front in six simple rounded lobes (Pl. 1, fig. 8). It is lined as usual by a reflected portion of the test, and a strong sphincter muscle is developed in its walls (Pl. 2, fig. 21). The oral tentacles (Pl. 1, fig. 8) are twelve in number, situated on a hexagonal ridge surrounding the base of the buccal siphon. Six of the tentacles, situated at the angles of the hexagon, are larger than the others which alternate with them. Separated from the tentacles by the "peribranchial zone" is the "peripharyngeal band," here apparently a simple ridge, not grooved as in Fragaroides. On the ventral side it is continuous with the anterior end of the endostyle, while on the dorsal side it appears to fuse, as in Fragaroides, with the small dorsal tubercle which bears the simple rounded opening of the subneural gland.

The branchial sac is large and comparatively simple. There are four rows of long and narrow stigmata, each row containing about twenty-four slits on each side (Pl. 2, fig. 12). Between the four rows three shelf-like membranes project into the interior of the sac. These are the "lames intersériales" of Maurice, and are continued round the circumference of the sac, being only interrupted by the endostyle. Along the middle of each row of stigmata runs a transverse vessel connected with each of the interstigmatic bars, but not otherwise interrupting the stigmata. A similar arrangement to this occurs in the genus Distaplia. On the dorsal side, but to the left of the middle line, each interserial lamella is produced into a large ciliated languet. Of these the two anterior are placed somewhat nearer the middle line than the third. A similar unsymmetrical position of the dorsal languets to the left of the middle line occurs according to Herdman in Distaplia rosea, and Maurice describes the same arrangement in Fragaroides.

The branchial sac is connected with the wall of the atrium by small trabeculæ placed at the level of the interserial lamellæ (Pl. 1, fig. 8). These are few in number, apparently only one on each side for each lamella, though I could not ascertain this with certainty. This condition presents the opposite extreme to that seen in Fragaroides, where an almost continuous membrane connects the branchial sac with the body-wall between each row of stigmata. The wall of the branchial sac, in contrast to that of Fragaroides, is here entirely without muscles, except for the longitudinal bands running in the lips of the endostyle and those at the sides of the dorsal sinus.

The minute structure of the interstigmatic bars agrees perfectly with that described by Maurice for Fragaroides. Along each side facing the cleft is the specialised stigmatic epithelium (Pl. 2, figs. 17 and 18), formed by six regular rows of ciliated cells. Each cell forms at its free end a narrow longitudinal ridge along which the cilia stand in a single row. The surfaces of the bar turned towards the branchial and atrial cavities are covered by simple flattened epithelium. In the centre is a blood-sinus bounded by the basement membrane of the epithelium.

The endostyle is large and much undulated. In transverse section (Pl. 2, fig. 20) it shows essentially the same structure as that of Fragaroides. The everted lips are covered by ciliated epithelium. At the bottom of the groove a narrow band of columnar cells bears the enormously long cilia characteristic of the Ascidian endostyle. On each side of the groove is the "glandular" epithelium, consisting of elongated curved cells tapering towards their free ends, and this side wall of "glandular" epithelium is divided into three parts by two small bands of ciliated epithelium. These two bands are here identical in structure, while in Maurice's account of Fragaroides the inner or more median of the two appears as a "troisième épithélium vibratile de caractères tout particulières." Just beneath each of the recurved lips of the endostyle a muscle-band runs along its entire length. At the posterior extremity the right lip is continued backwards as a ciliated ridge ("raphé postérieur") which becomes continuous with the œsophageal funnel.

Digestive Tract.—The funnel-shaped opening of the œsophagus into the branchial chamber is large and convoluted (Pl. 2, fig. 13), and the columnar ciliated œsophageal epithelium which covers it is sharply marked off at its edge from the flattened epithelium of the branchial sac. Close to the free surface of the œsophageal epithelium is a layer of deeply staining granules of unknown nature. The œsophagus has thick and convoluted walls (Pl. 2, fig. 19), and its hinder end projects for a little distance into the stomach, where it forms a sort of valvular opening (Pl. 2, fig. 23).

The stomach (Pl. 1, fig. 4) has the form of an oval sac, smooth on the outside but having the lining epithelium thrown into oblique longitudinal folds. This epithelium is very badly preserved in all our specimens, but it can be seen that the cells are columnar and stain deeply.

Embedded in the lining epithelium of the stomach, or lying free in its cavity, are certain large oval or pyriform cells (Pl. 2, fig. 25). These have sharp outlines and very granular protoplasm, stained only faintly by hæmatoxylin and not at all by carmine. The nucleus is large and transparent, and contains a large deeply-staining nucleolus. In one or two cases a small segment, marked off from one end of the cell as shown in fig. 25 *a*, confirms a belief suggested by the nuclear and other characters that these are parasitic Gregarines.

A slight constriction separates the stomach from the intestine (Pl. 2, fig. 23). The latter is of nearly uniform diameter throughout its length, there being no division into duodenum, chylific ventricle, and rectum. Its walls are slightly folded, and it is lined throughout by columnar epithelium. The terminal part projects slightly into the cloacal chamber, forming what Maurice calls a "pavillon anale," but I have failed to find an anal sphincter, though such in all probability exists.

The intestinal gland is well developed. A series of tubules ramifies over the surface of the intestine (Pl. 2, fig. 24); these are lined by somewhat irregular cells, and unite to form a duct which crosses the intestinal loop to open into the stomach at about its middle (Pl. 2, fig. 23).

Nervous System.—The nerve-ganglion is oval in form, and gives off numerous nerves. Two large nerves in front and a large median nerve (the cloacal), flanked by two smaller lateral ones behind, are easily seen; but it was found impossible to determine the number or arrangement of the smaller lateral nerves.

On the dorsal wall of the dorsal blood-sinus a slight thickening composed of a few small cells (Pl. 2, fig. 22) represents the "cordon viscéral ganglionnaire" of van Beneden and Julin, the remains of the central nervous axis of the larva. In a fortunate series of sections this cord can be traced into connection with the cerebral ganglion, which it enters at the root of the cloacal nerve.

In minute structure the ganglion corresponds exactly with that of Fragaroides (Pl. 2, fig. 21). Outside is a layer of large nerve-cells, finely granular and with conspicuous nuclei, sending processes inwards—the "grey matter" of Julin,—while the interior is composed of the usual fibrillated "punktsubstanz"—the "white matter" of Julin.

Subneural Gland.—The subneural gland (Pl. 2, fig. 21) is very feebly developed, consisting merely of a thin layer of cells lying on the posterior face of the nerve-ganglion, separated from it in the middle line by a space representing the backward continuation of the duct. The tissue of the gland consists of ill-defined rounded cells, many of them containing vacuoles.

The duct, on the other hand, is well developed and normal in structure. As in Fragaroides, its anterior wall is continued back over the posterior face of the ganglion for some distance, while the ventral wall stops short of this and becomes continuous with the band of glandular tissue. The columnar epithelium lining the duct is reflected at its mouth over the "dorsal tubercle," and in the interior of the duct bears the usual long cilia, one to each cell.

It is interesting to note that the extreme degeneracy of the gland itself (carried to a greater degree, I think, than has been described in any other Ascidian) is not associated with any corresponding reduction in the size of the duct. Indeed, even in other cases where the gland is much better developed (e. g. Fragaroides), the duct, both in respect to size and to the richness of its ciliation, seems out of all proportion to any secretory function we can ascribe to the gland.

Circulatory System.—The heart in its pericardium lies on the ventral side of the intestinal loop (Pl. 1, fig. 4; Pl. 2, fig. 16). It is a thin-walled, somewhat fusiform tube, but I was unable to trace any vessels connected with it. A space lined by endothelium and lying to the left of the pericardium may possibly represent a vestige of the epicardial system. A large blood-sinus runs along the dorsal edge of the branchial sac (Pl. 2, figs. 14 and 22); in its lateral walls run strongly developed longitudinal muscle-bands, while in the middle of its dorsal wall runs the ganglionic nerve-cord above alluded to.

The "vascular process" arises near the hinder end of the abdomen, a little to the left side. In the substance of the test these processes branch and probably anastomose, and finally end in club-shaped dilatations (Pl. 1, fig. 6). In section (Pl. 3, fig. 32) each is seen to consist of a simple tube of ectoderm divided into two by a median partition of thin and apparently structureless membrane. No internal layer of connective tissue, as described by Herdman in Colella, could be distinguished, the processes appearing to be exclusively ectodermal, like the "stolons" of Botryllus (Hjort, 'Mitt. Zool. Stat. Neap.,' x, p. 589), a point which is of interest in connection with the probable origin of buds from them. Numerous blood-corpuscles occur in the cavity of these tubes.

Sexual Organs.—The sexual organs lie on the dorsal side of the intestinal loop, the ovary being external or dorsal to the testis. In all the individuals examined several ova were found in various stages of development, the largest being about ·6 mm. in diameter. They are contained in follicles opening by short canals into the oviduct (Pl. 3, fig. 27). No very young ova were seen, the smallest being about ·1 mm. in diameter, and nowhere did the ovary present in section the bilateral T-shape described by Maurice in Fragaroides and by van Beneden and Julin in Clavellina. Inside the wall of the follicle in all save the youngest there is a loose layer of cells outside the egg-membrane (Pl. 3, fig. 28). This seems to correspond to the inner of the two layers into which the follicular wall splits in Clavellina according to van Beneden and Julin ('Arch. de Biol.,' vi, p. 358), though in the latter case the splitting does not take place until the ovum is nearly ripe. Inside the egg-membrane are the characteristic and problematical "test-cells," with large nuclei each containing several nucleoli, and scanty protoplasm. The vitellus becomes more and more coarsely granular as the egg matures, and in the oldest eggs it is broken up into numerous irregular yolk-masses. The oviduct is a thin-walled tube running up alongside the vas deferens (Pl. 2, figs. 15 and 16).

On the dorsal surface of the animal's thorax, near its junction with the neck and rather to the left of the mid-dorsal line, there is attached by a narrow neck a spherical thin-walled vesicle of about ·5 mm. in diameter (Pl. 1, fig. 3). The wall of this vesicle is composed of two layers, the outer continuous with the ectoderm of the thorax, while the inner seems to be continuous with the wall of the oviduct. It is difficult to make out the exact relations of the parts, but I believe that the lumen of the oviduct opens into the vesicle. This organ occupies the position of the incubatory pouch possessed by so many Compound Ascidians, and its apparent connection with the oviduct naturally suggests that it represents that structure, though I have never found eggs or larvæ in it in a single instance.

In nearly all the specimens examined hardly a trace of testis could be found, although the vas deferens was usually full of spermatozoa. In one or two cases, however, the testis was developed. It consisted (Pl. 3, fig. 26) of a number of follicles lying in the connective tissue in the intestinal loop, connected by branching tubes with the vas deferens and showing groups of developing spermatozoa in each. In one specimen (badly preserved, unfortunately) the follicles are considerably larger than those figured, and the lower part of the vas deferens is very much distended (to ·3 mm. diameter) with spermatozoa. No definite relation between the states of maturity of ovary and testis such as would suggest the occurrence of protandry or protogyny could be demonstrated.

The vas deferens is usually about ·06 mm. in diameter, and is composed of cubical epithelium, probably ciliated. Its hinder part is much convoluted, though not spirally coiled as in the Didemnidæ; in front it pursues an undulating course to open close beside the anus.

The spermatozoa are linear, slightly curved, about ·001 mm. in length, and bear long flagella.

Buds.—Numerous buds in various stages of development are scattered in the substance of the test just below the layer of ascidiozooids. All of them, even the youngest, lie quite free and unattached, usually alongside a vascular process (Pl. 1, figs. 5 and 6). In no case did I succeed in tracing a connection with the parent animal, and the origin of the buds must therefore be left undecided—more particularly since Hjort ('Mitt. Zool. Stat. Neap.,' x, pp. 588 and 589) has contested Herdman's account of the process of "stolonial" budding in the Botryllidæ. In view of the obscurity still involving many points in the process of bud development in the Tunicata, it did not seem advisible to attempt a detailed examination of our very minute and imperfectly preserved specimens. One point of interest, however, is the presence of several large cells, apparently ova, in all the buds examined (Pl. 3, figs. 29—31). The appearance of these buds with their contained ova closely resembles those figured by Kowalevsky in Distaplia ('Arch. f. mikr. Anat.,' x, 1874). Herdman also notices the early appearance of ova in the buds in several cases (e. g. Colella), and Hjort (l. c., pp. 604 and 605) has recently called attention to the migration of the egg-cells from the parent animal into developing buds in the case of Botryllus. It is possible that we have here to do with an instance of such migration, but on the other hand, if the buds arise, as seems probable, from the "vascular processes," it is very difficult to see how the ova could have reached their destination.

The youngest buds (Pl. 1, fig. 6, and Pl. 3, fig. 29) consist of a two-layered vesicle, the space between the layers containing loosely scattered cells and one or two ova. Older buds (Pl. 1, fig. 5, and Pl. 3, fig. 31) show the two peribranchial cavities developed at the sides of the branchial sac. In the latter the endostyle can be seen in sections as a pair of ridges near its anterior end. The neural tube lies dorsally to the branchial sac, but its communication with the latter could not be traced. In sections of the abdominal region (Pl. 3, fig. 30) the rudiment of the heart is seen in its pericardium, and on either side of the latter are the two "epicardial tubes," which, as has been already stated, are in this genus absent or rudimentary in the adult, but which in Fragaroides persist as a great space running the whole length of the body. A long "tail" projecting from the hinder end of the older embryos (Pl. 1, fig. 5) is probably the outgrowing vascular process.

Systematic Position.—The unnamed genus referred to by Professor Herdman as —— (?) ignotus, and already mentioned above, is so similar in general appearance as well as in habitat to the form here described that the two must be nearly related, if not identical. The poor state of Professor Herdman's specimens, which accounts for the brevity of his description, may also account for certain discrepancies, as for instance when Professor Herdman describes the tentacles as numerous and equal, and the nerve ganglion as spherical in form. Our species, however, certainly does not belong to the Polyclinidæ, to which Herdman refers his —— (?) ignotus "from the general appearance of the colony and of the ascidiozooids." The genus being certainly nondescript and requiring a name, I give the animal at the same time a new specific one in the face of what uncertainty remains as to its identity with Professor Herdman's type.

As regards the affinities of the new genus, we are confronted by the fact that the diagnoses of recognised families appear to be somewhat artificial, and certainly do not lend themselves very readily to the reception of new forms. Taking, however, the received families as they at present go, Julinia is obviously excluded from the Polyclinidæ by the absence of a post-abdomen. This negative character, together with the distinct separation of thorax from abdomen, are characters common to the three families of Distomidæ, Didemnidæ, and Diplosomidæ. From the last two families our species is excluded by the absence of retractile muscles in the vascular processes, by the large anal languets (absent in Giard's definition from the Diplosomidæ), by the want of the calcareous spicules so characteristic of the Didemnidæ, and by the characters of the testis and vas deferens, which latter in the Didemnidæ is spirally coiled round the single large testis. Narrowing down our genus accordingly to the Distomidæ, we find that it agrees with that family in the numerous spermatic vesicles of the testis, as well as with individual genera of that family in its incubatory pouch and large atrial languet. The incubatory pouch is common to Colella and Distaplia, while the atrial languet is absent in Colella. The general sum of the characters, then, seems to bring our genus nearest to Distaplia, with which latter genus it further agrees in the characters of the branchial sac with its four rows of long stigmata crossed by intermediate transverse vessels. It differs chiefly from the definition of Distaplia in the form of the colony, as well as in the ascidiozooids being embedded in the test instead of forming prominent knobs or lobes.

The following is the diagnosis of the new genus:

JULINIA, gen. nov.

Colony cylindrical, excessively elongated; ascidiozooids completely embedded in the fleshy or gelatinous test; systems distinct, with well-developed common cloacal cavities; buccal orifices small, six-lobed; common cloacal orifice large, irregularly lobed; zooids with thorax and abdomen united by a narrow neck; atrial languet very large; vascular process well developed; branchial sac rather large, with four rows of long stigmata crossed by narrow intermediate bars; dorsal languets large, three in number, placed to the left of the middle line; stomach with internal longitudinal folds.

Species.—Julinia australis, n. sp., with the characters of the genus.

Habitat.—Antarctic Ocean.

EXPLANATION OF PLATES 1—3,

Illustrating Mr. W. T. Calman's paper "On Julinia, a New Genus of Compound Ascidians from the Antarctic Ocean."

Reference Letters.

atr. l. Atrial languet. *b.* Bud. *b. l.* Buccal lobes. *b. s.* Buccal siphon. *b. sph.* Buccal sphincter muscle. *bl. c.* Bladder cells of test. *bl. g.* Blood-corpuscles. *br. s.* Branchial sac. *c. cl. o.* Common cloacal orifice. *cl. o.* Cloacal orifice. *cl. n.* Cloacal nerve. *d. l.* Dorsal languet. *d. n.* Dorsal ganglionic nerve-cord. *d. s.* Dorsal branchial sinus. *d. t.* Dorsal tubercle. *ect.* Ectoderm. *end.* Endostyle. *epc.* Rudiment of epicardial system (?) in adult. *epc. t.* Epicardial tubes in bud. *fl.* Outer layer of follicular wall of ovary. *fl″.* Inner layer of follicular wall of ovary. *gl.* Subneural gland. *ht.* Heart. *inc. p.* Incubatory pouch. *int.* Intestine. *int. l.* Interserial lamina of branchial sac. *int. gl.* Intestinal gland. *int. d.* Duct of intestinal gland. *l. m.* Longitudinal muscle-bands. *n. g.* Nerve gland. *œs.* Œsophagus. *œs. f.* Œsophagus funnel. *ov.* Ova. *ovy.* Ovary. *ovd.* Oviduct. *pbr.* Peribranchial cavity. *p. c.* Pigment corpuscles. *per.* Pericardium. *p. ph. b.* Peripharyngeal band. *r. p.* "Raphé postérieur." *st.* Stomach. *t. c.* "Test-cells" of ovum. *t. c′.* Test-cells. *tr.* Trabeculæ from branchial sac to mantle. *tr. b.* Intermediate transverse bars of branchial sac. *ts. t.* Tubules of testis. *v. d.* Vas deferens. *v. p.* Vascular process.

PLATE 1.

FIG. 1.—General view of colony slightly reduced.

FIG. 2.—A single system of ten individuals × 7. In the centre of the system is the irregularly-lobed cloacal orifice; on the outer side of each ascidiozooid the endostyle is seen shining through.

FIG. 3.—A single ascidiozooid seen from the left side × 20. This figure illustrates the form of the branchial sac, the convoluted endostyle, and the relations of the incubatory pouch and atrial languet. In the abdomen the ovary and part of the vas deferens are seen on the dorsal side of the intestinal loop.

FIG. 4.—Ventral view of abdominal region, showing the oblique folds in the stomach wall, and the position of the heart and part of the vas deferens in the loop of the gut. The origin of the vascular process is seen on the lower side of the intestine.

FIG. 5.—Bud lying beside vascular process.

FIG. 6.—Younger bud near club-shaped end of vascular process.

FIG. 7.—View of part of common cloacal chamber seen from within, showing four atrial languets pointing inwards and meeting together. In one individual of the system the oral region is also shown. The roof formed to the common cloacal chamber by these converging atrial languets is not to be seen from the outside, it being covered in its turn by a second roof of test-substance.

FIG. 8.—Oral region of an ascidiozooid seen from within, showing the six-lobed buccal orifice, the hexagonal ring of twelve tentacles, the peripharyngeal band connected dorsally with the dorsal tubercle and ventrally with the endostyle; the nerve ganglion, the first row of stigmata, and the trabeculæ connecting the stigmatic wall with the atrial wall are also seen.

FIG. 9.—Transverse section through one half of the colony × 4, showing the position of the ascidiozooids, the distribution of the vascular processes through the matrix of the colony, and the zone of problematic vesicles referred to on p. 3 as possibly representing degenerated zooids.

FIG. 10.—Cell elements from the test supposed (p. 4) to be phagocytes. Zeiss, $\frac{1}{12}$th hom. imm., 2.

FIG. 11.—Spicules from test. Zeiss, D. D., 2.

PLATE 2.

Fig. 12.—Internal view of dorsal portion of branchial sac, showing the four rows of stigmata, the transverse vascular bars which cross them, the unsymmetrical position of the three dorsal languets, and the interserial lamellæ with which these latter are connected.

Fig. 13.—The œsophageal funnel and its connection with the endostyle.

Fig. 14.—Semi-diagrammatic transverse section across the thorax at the level of the cloacal opening, showing the proportions of the endostyle and the relations of the dorsal sinus and the degenerate rudiment of the dorsal nerve-cord.

Fig. 15.—Transverse section through the constricted neck between thorax and abdomen, showing the relations of œsophagus and intestine to vas deferens and oviduct.

Fig. 16.—Transverse section through upper portion of abdomen, showing the stomach and intestine in relation to vas deferens and oviduct, and to the heart, pericardium, and (?) epicardial tubes.

Fig. 17.—Transverse section of an interstigmatic bar, showing the contained blood-sinus, the characters of the ciliated epithelium on its lateral edges, and of the flattened epithelium on its inner and outer sides. Zeiss, $\frac{1}{12}$th hom. imm., 2.

Fig. 18.—Surface view of an interstigmatic bar.

Fig. 19.—Transverse section of œsophagus, showing its folded walls and columnar ciliated epithelium.

Fig. 20.—Transverse section of endostyle, showing the epithelial characters of its lips, side walls, and central groove. Zeiss, E, 2.

Fig. 21.—Ventral section of nerve ganglion and associated organs, showing the buccal sphincter, the ganglion with origin of the cloacal nerve, the gland of Julin, and the course of its duct. The long and well-preserved cilia in the duct are all pointing inwards. Zeiss, E, 2.

Fig. 22.—Transverse section of the dorsal branchial blood-sinus, showing dorsally the rudimentary dorsal nerve-cord, and laterally, near the attachment of the sinus to the thoracic walls, its longitudinal muscular bands. E, 2.

Fig. 23.—Longitudinal section of the abdomen, showing the valvular lip of the œsophagus where it enters the stomach, and the entrance into the latter organ of the duct of the intestinal gland. Some tubules of the testis are again seen within the intestinal loop.

Fig. 24.—Longitudinal section of part of the intestinal gland. The gland is seen lying against the wall of the intestine, while its duct passes off in the opposite direction towards the stomach. Zeiss, $\frac{1}{12}$th hom. imm., 2.

Fig. 25.—Gregarines from stomach. Zeiss, $\frac{1}{12}$th hom. imm., 2.

PLATE 3.

Fig. 26.—A portion of the testis, showing its racemose follicles containing spermatozoa. Zeiss, $\frac{1}{12}$th hom. imm., 2.

Fig. 27.—Part of the ovary, showing one ovarian follicle and a portion of another, both in connection with the oviduct. D D, 2.

Fig. 28.—Peripheral layer of ovum with its test-cells, surrounded by the two-layered follicular wall. Zeiss, $\frac{1}{12}$th hom. imm., 2.

Fig. 29.—Transverse section of a young bud, showing included ova. Zeiss, D D, 2.

Fig. 30.—Transverse section of abdominal region of older bud. In this section we see, besides the œsophagus, the intestine, and a large ovum, the developing heart within its pericardium and the two associated epicardial tubes. D D, 2.

Fig. 31.—Optical longitudinal section of a bud of about the same age as that represented in Fig. 30. The branchial sac and the paired rudiments of the atrium are here shown. D D, 2.

Fig. 32.—Transverse section of a vascular process, with its surrounding space and adjacent portions of the test-substance. Large bladder-cells, small test-cells, and pigment corpuscles are seen within the matrix of the latter.